International Journal of Electrical and
Electronics Engineering Research (IJEEER)
ISSN(P): 2250-155X; ISSN(E): 2278-943X
Vol. 5, Issue 2, Apr 2015, 41-50

OPTIMAL ALLOCATION AND CONTINGENCY ANALYSIS WITH MULTIPLE EMBEDDED GENERATION UNITS IN RADIAL DISTRIBUTION NETWORK USING GA

KOTA SHIRISHA REDDY, L. RAMADEVI, G. SRAVANTHI & KOGANTI SRI LAKSHMI

Assistant Professor, Department of EEE, SNIST, Hyderabad, Telangana, India

ABSTRACT

The integration of embedded generation (EG) units into the distribution system brings technical and economic benefits to the power system network. But, placement of EG's at non optimized locations can effect voltage profile with increased system losses. This paper intends the optimal placement and contingency analysis of several Embedded Generation (EG) units in distribution network using Genetic Algorithm (GA). The main intention is to diminish the total real power losses with proper voltage profile. It go behinds the conversation of evaluating the effect of the location and the size of EG to the system before and after contingency is created in the system by fault. The projected allocation method and contingency analysis is verified using IEEE-33 and 69 bus radial distribution systems. The algorithm has been programmed in MATLAB and results are compared.

KEYWORDS: Genetic Algorithm (GA), Embedded Generation (EG), Contingency Analysis

INTRODUCTION

In recent years, due to the increasing interest on renewable sources such as wind, solar, geothermal, biomass and ocean energy, all over the world, the number of studies on embedded generation (EG) has rapidly increased and makes EG units cost effective. By this, injection of embedded generation systems to distribution networks not only diminishes the power losses but also improves voltage profile of the network.

The problem of global warming and exhaustion of fossil fuel have fostered the increased usage of less environmentally-polluting embedded generation (EG) sources closer to load demands in the distribution system [5]. EG units are rapidly increasing and becoming an impressive alternative to grid for reliability and ability to exploit renewable energy sources.

Literature survey shows that a lot of work has been done on optimal location and size of EG units in distribution networks. Some of such studies are: Tabu search [1], Artificial Intelligence (AI), Evolutionary computation, fuzzy-GA algorithm, Ant Colony Search Algorithm (ACSA) [2], Particle Swarm Optimization (PSO) are some of popular optimization techniques that are normally used to solve this type of problems. The associated works is carried on GA for optimal placement of EG using MATLAB as a tool for solving that problem which has been proposed in. In additionally we worked on multiple EG's with and without contingency analysis.

This paper provides solution for problem of optimal allocation and contingency analysis by using Topology based load flow solution technique [3] with genetic algorithm by considering EG as PQ model. When compared to other search techniques in this proposed technique convergence is fully guaranteed and computation time is very Minimum

TOPOLOGY BASED LOAD FLOW SOLUTION

In Distribution networks R/X ratio is very high and due to this, these networks are unconditional and conventional therefore Newton-Raphson (NR) and fast decoupled load flow (FDLF) methods are inaccurate in providing solution for such type of networks. Here in this paper, Topology based approach is used [4]. This proposed technique contains only evaluation of a simple algebraic expression of voltage magnitude without caring of trigonometric terms so that it eliminates the complex process of identifying nodes connected beyond a particular node. The two matrices, bus injection to node power matrix [BINP] and line loss to node power matrix [LLNP] are created based on connectivity of network. Under assumption that shunt capacitance is negligible at the distribution voltage level chance of convergence is fully possible.

It is assumed that the three-phase radial distribution networks are balanced. This assumption is quite valid for 11kV rural distribution feeders in India and elsewhere.

Formation of BINP, LLNP Matrices

Let us Consider 6- Bus Radial Distribution Network (figure 1)

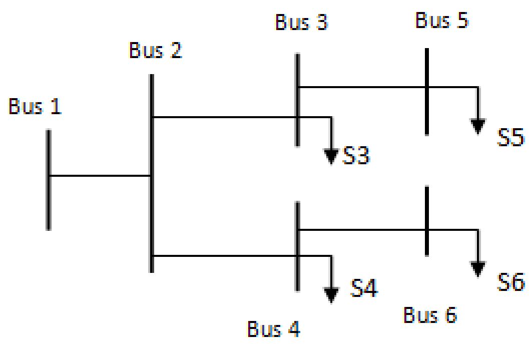

Figure 1: Sample 6-Bus Radial Distribution System

Bus-Injection to Node Power Matrix (BINP) Matrix

For fig1.1.1, N2, N3, N4, N5 and N6 are the equivalent powers at each Node.

N2= S3+ S4 + S5 + S6

N3 = S3 + S5

N4 = S4+ S6

Where S3, S4, S5 and S6 are complex load powers at buses 3, 4, 5 and 6 respectively

[N] = [BINP] [S] (1)

$$\begin{bmatrix} N2 \\ N3 \\ N4 \\ N5 \\ N6 \end{bmatrix} = \begin{pmatrix} 1 & 1 & 1 & 1 \\ 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} * \begin{pmatrix} S3 \\ S4 \\ S5 \\ S6 \end{pmatrix}$$

Line Loss to Node Power matrix (LLNP) matrix: The relation between the line losses and node power can be obtained by following equations:

$N2' = SL1 + SL2 + SL3 + SL4 + SL5$

$N3' = SL4$

$N4' = SL5$

Complex power losses associated with lines 1, 2,3,4,5 are given by SL1, SL2, SL3, SL4 and SL5 respectively. Sum of the line losses appearing at Node 2, 3, 4, 5 and 6 are given by N2', N3', N4', N5', N6'.

[N'] = [LLNP] [SL] (2)

$$\begin{bmatrix} N2' \\ N3' \\ N4' \\ N5' \\ N6' \end{bmatrix} = \begin{bmatrix} 0 & 1 & 1 & 1 & 1 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix} * \begin{bmatrix} SL1 \\ SL2 \\ SL3 \\ SL4 \\ SL5 \end{bmatrix}$$

Effective load at each node = N + N (3)

The algorithm to solve the load low problem is given below.

- Read the system data, V1= 1.0 p.u. Line losses are assumed to be zero in the first iteration.
- Build BINP matrix and LLNP matrix.
- Obtain $P_{\text{effective}} + j*Q_{\text{effective}}$, at each node.
- Initialize iteration count =1
- Obtain receiving end voltages using V2=√ (B[j]-A[j]) and power loss on all lines using $\mathbf{P_{LOSS}[j]} = R[j]*(P_2^2+Q_2^2)/V_2^2$, $Q_{LOSS}[j] = X[j]*(P_2^2+Q_2^2)/V_2^2$ and $S_{LOSS} = P_{LOSS} + JQ_{LOSS}$
- Multiply the power loss column matrix, SL with LLNP matrix to get N' matrix. N' represents the part of line losses in the effective load at various nodes.[N'] = [LLNP] [SL]
- Calculate the total effective load at various nodes by adding the N and N' matrix. Effective load at each node = N + N'
- Increment the iteration count Repeat the steps from step (5) using new effective loads at every node.
- If the difference in the voltages between present iteration and previous iteration is greater than 0.001 pu, then increment the iteration count and repeat from step (5), otherwise, print the result.

FUNCTION OF GA IN OPTIMAL PLACEMENT AND SIZING OF EG

The genetic algorithm (GA) is an optimization and searching technique which operates on the principle of genetics and natural selection [6], [7]. Here, continuous or floating GA is used as it is having a benefit of exact representation of the continuous parameter.

Continuous Genetic Algorithm (GA) is used to determine the optimal placement and size of Embedded Generation units in the distribution system in order to diminish the total losses in the system. By reducing these losses, the voltage profile at each bus is expected to be enhanced [8]. This scheme needs load flow to run for several times. Later, getting the optimal placement and size simultaneously for Embedded Generation (EG), the algorithm is finished.

The objective function is the results of total loss of the system, Ploss to be minimized, H as follows:

$$H=\sum_{j=1}^{nline} Ploss$$

Where, nline is number of lines in the system, Ploss is the real power losses at each bus, H is the total real power losses that are to be minimized.

T he total length of chromosome is equal to (number of EG’s x 2*).* the first variable represents the location and the second one represents the size of EG in chromosome.

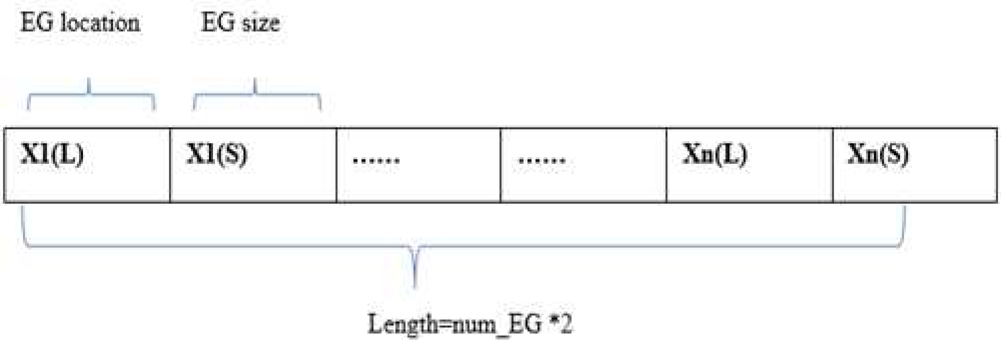

Figure 2: Chromosome

After evaluating each chromosome, the objective function is transformed and normalized to a fitness scheme to be maximized as follows:

f=1/ (1+H), **f** is the fitness function that is to be maximized. v

CONTINGENCY ANALYSIS

Contingency analysis is the study of the outage of elements such as transmission lines, transformers and generators, and investigation of the resulting effects on line power flows and bus voltages of the remaining system. It is important for both the system operator and the system planner to be able to evaluate how the line flows and bus voltages will be altered in the new steady state. Overloads due to excessive line currents must be avoided and voltages that are too high or too low are not acceptable because they render the system more vulnerable to follow on cascading outages. The large numbers of possible outages are analyzed by means of contingency analysis. Great precision is not required in contingency analysis since the primary interest knows whether or not an insecure or vulnerable condition exists in the steady state following any of the outages [9].

This chapter focuses on the IEEE-33 and IEEE 69-bus test systems on which the analysis is done by introducing the contingency situation which is referring to the fault (i.e. line 3- 28 in IEEE-69 and line 2-19 in IEEE-33) to see the impact of EG that has or have been installed in the system. The study will emphasize on the changes of voltage profile and the system losses before and after reconfigurations caused by the fault with EGs. However, the type of faults is not to be considered since it is assumed that the system is reconfigured after the isolation of the fault. This study will help in finding the trends of optimal size and location of EG’s in these test systems.

OPTIMAL ALLOCATION STUDY AND DISCUSSIONS

The proposed method has been tested on IEEE-33 and 69 bus radial distribution systems. The algorithm has been

programmed in MATLAB and the test system can be obtained.

The GA properties are as follows:

- Mutation probability, pm = 0.5
- Selection=0.5
- Population = 50
- Number of EG units = up to5

The reason for using 5 units of EG's that there is no considerable reduce in real losses when adding EG units more than 5.

Variation of Total Power Losses with Respect to Iterations for IEEE-33 and 69 Bus Systems without Contingency:

From the figure 3 it is clear that, for IEEE-33 bus system the Real power losses without placing EG is 0.308PU, while connecting 5 EG units, active power losses are reduced to 0.0195 PU. The total real power losses are decreased by 93.66% and for IEEE-69 bus system minimum active power losses of the given distribution network are 0.0205PU while connecting 5 EG units at optimal locations the total real power losses are reduced 0.0063PU.

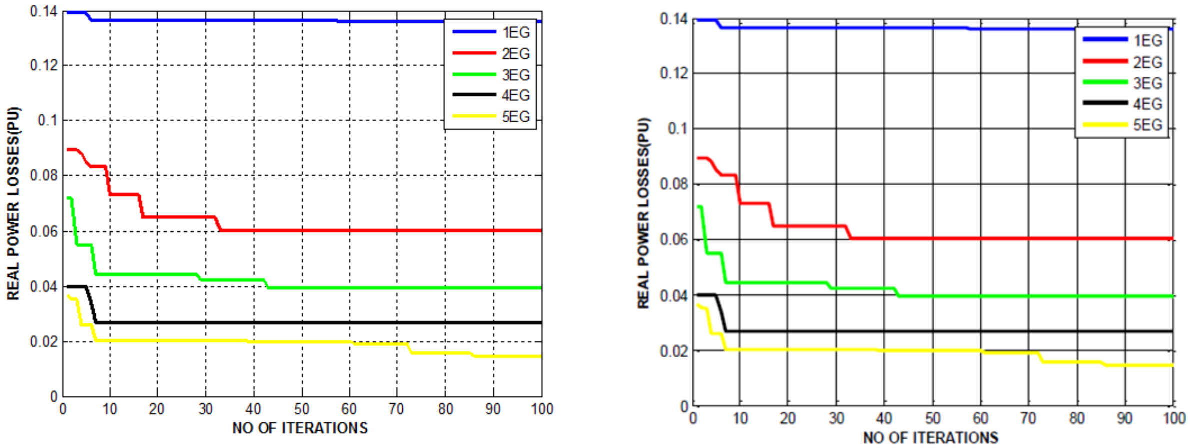

Figure 3: Total Real Power Losses Vs Iterations for IEEE- 33 and 69 Bus Systems with EG's and without Contingencies

Table 1: Effect of Multiple Placement of EG Units without Contingency on IEEE- 33 and 69 Bus Systems

No of EG Units	IEEE 33 Bus System			IEEE 69 Bus System		
	Embedded Generation		Total Real Power Losses(PU)	Embedded Generation		Total Real Power Losses(PU)
	Size (PU)	Locations		Size (PU)	Locations	
No EG	-	-	0.308	-	-	0.206
1 EG	1.5338	13	0.1647	0.6464	63	0.0215
2 EG	1.0936, 1.0846	19,30	0.0707	0.5672,1.1962	69,63	0.0162
3 EG	1.1230,1.7204 , 1.1465	9,19,20	0.0453	0.4121,1.1132,0.0772	61,6,47	0.0107
4 EG	1.0921,0.9882,1 .1023,1.0831	10,13,16,1 8	0.0259	1.4898,1.3809,0.4098, 1.2123	59,64,47,5 8	0.0084
5EG	1.0696,0.9949,1 .1127,0.9585,1. 3856	10,18,22,2 6,31	0.0195	0.8143,0.5173,0.5882, 0.1535,0.6718	38,49,51,5 3 ,63	0.0063

Voltages at Different Buses for IEEE- 33 and 69 Bus Systems without Contingency

From figure 4 It can be observed that when EG units are inserted in distribution network the voltage profile is improved from without EG to with 5EG units.

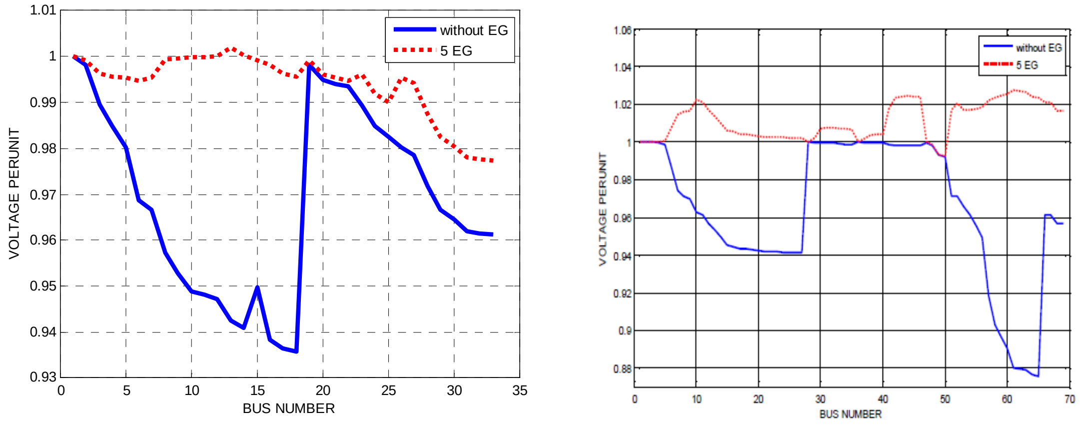

Figure 4: PU Voltages at Different Busses for IEEE- 33 and 69 Bus Systems with and Without EG's

Variation of Total Power Losses with Respect to Iterations for IEEE- 33 and 69-Bus Systems with Contingency

From the figure 5 it is clear that ,for IEEE-33 bus system, the Real power losses without placing EG is 0.2606PU, while connecting 5 EG units, active power losses are reduced to 0.0196 PU. The total real power losses are decreased by 98.2% and for IEEE-69 bus system, minimum active power losses of the given distribution network are 0.196PU while connecting EG units at optimal locations the active power losses are reduced to 0.0156PU.

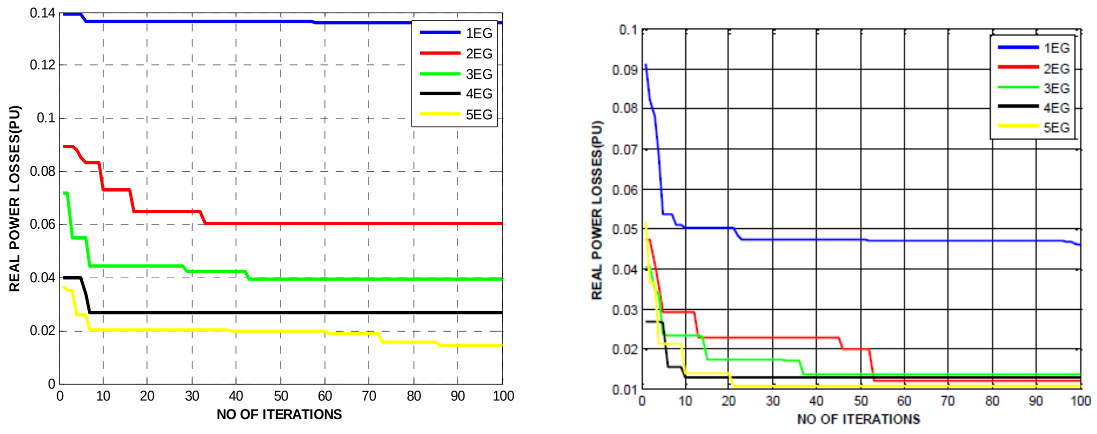

Figure 5: Total Real Power Losses Vs Iterations for Ieee-33 and 69 Bus Systems with EG's and with Contingencies

Table 2: Effect of Multiple Placements of EG Units with Contingency on IEEE- 33 and 69 Bus Systems

No of EG Units	IEEE 33 Bus System			IEEE 69 Bus System		
	Embedded Generation		Total Real Power Losses(PU)	Embedded Generation		Total Real Power Losses(PU)
	Size (PU)	Locations		Size (PU)	Locations	
No EG	-	-	0.2606	-	-	0.196
1 EG	1.2953	11	0.1362	1.2537	61	0.0426
2 EG	0.9687,1.2604	16,27	0.066	1.5237,0.5326	61,39	0.0298

Table 2: Contd.,

3 EG	0.7429 ,1.6654,1.1225	18,25,27	0.0424	0.2352,1.4387, 0.1133	4,27,50	0.0203
4 EG	0.5665,1.3878, 0.6069,1.6769	8,14,16,25	0.0231	0.0320,1.2650, 1.1938,0.5099	3,15,50,51	0.0194
5EG	1.7000,1.5801, 0.465,0.8817,1.0706	6,14,16,21,28	0.0196	1.4591,0.5851, 0.5798,0.559,0.5672	3,4,56,61,24	0.0156

Voltages at different buses for IEEE 33 and 69 bus systems with contingency:

From figure 6. It can be clearly observed that when EG units are inserted in distribution network the voltage profile is improved from without EG to with 5EG units.

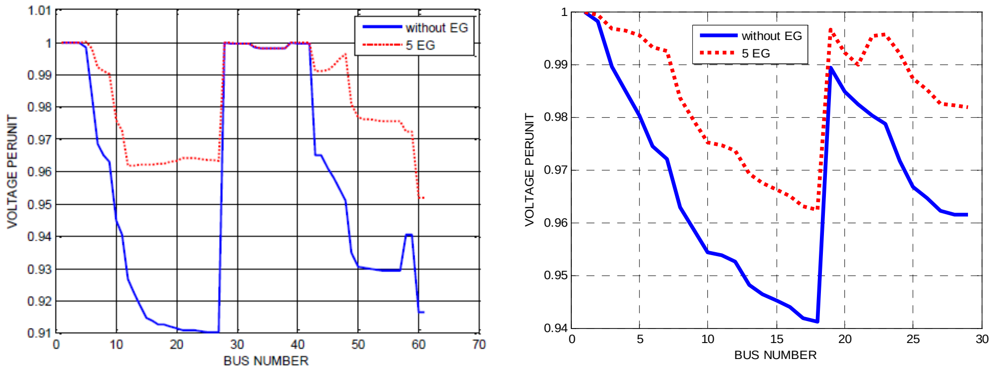

Figure 6: PU Voltages at Different Busses for IEEE- 33 and 69 Bus Systems with Contingencies

From the table 3, it is clear that the real power losses are reducing when EG is placed at optimal location and with optimal size. The percentage improvement from without EG to 5 EG is around at 90 in every case i.e. with contingency and without contingency.

Table 3: Comparison Table

Type of Standard Bus		Total real power losses (PU)		
		Without EG	5EG	% Improvement
IEEE-33 Radial Bus System	Without contingency	0.308	0.0195	93.66
	With contingency	0.2606	0.0196	92.47
IEEE-69 Radial Bus System	Without contingency	0.2063	0.0063	96.94
	With contingency	0.1960	0.0156	92.04

CONCLUSIONS

This paper provides a continuous GA for determining optimal placement and sizing of EG units. Here, Multiple EG installation cases were studied using IEEE 33 bus distribution system. The results demonstrated and emphasized that multiple EG installations decreased total real power losses more than single EG installations. However, multiple DG installations may result in unnecessary additional costs. In this paper “Topology based approach for Load flow Solution of Radial Distribution Networks” is used which is simple, efficient and accurate method.

REFERENCES

1. Caisheng, W. and M. Hashem-Nehrir, 2004. Analytical approaches for optimal placement of distributed generation sources in power systems. IEEE Trans. Power System. 19(4): 27-34.
2. R. Srinivasa Rao "Capacitor Placement in Radial Distribution System for Loss Reduction Using Artificial Bee Colony Algorithm" World Academy of Science, Engineering and Technology 68 2010.
3. K. V. S. Ramachandra Murthy, M. Ramalinga Raju, G. Govinda Rao, and K. Narasimha Rao "Topology based approach for Efficient Load flow Solution of Radial Distribution Networks" 16th National Power Systems Conference, 15th-17thdecember, 2010.
4. D. Das, D. P. Kothari, A Kalam "Simple and effcient method for load flow Solution of Radial distribution networks", Journal of Electrical Power and Energy Systems, Vol 17, No.5, pp335 – 346, 1995.
5. EI-hattam, W. and M. M. A. Salma, 2004. Distributed generation technologies, definitions and benefits. Electric Power Sys. Res., 71: 119-1283.
6. T. K. A Rahman, S. R. A Rahim, and I. Musirin, "Optimal allocation and sizing of embedded generators," in Power and Energy Conference, 2004. ECon 2004. Proceedings. National, 2004.
7. M. F. AIHajri, M. R. AIRashidi, and M. E. El-Hawary, "Hybrid Particle Swarm Optimization Approach for Optimal Distribution Generation Sizing and Allocation in Distribution Systems," in Electrical and Computer Engineering, 2007. CCECE 2007. Canadian Conference from 22-26 April 2007.
8. Y. Alinejad-Beromi, M. Sedighizadeh, M. R. Bayat, and M. E. Khodayar, "Using genetic algorithm for distributed generation allocation to reduce losses and improve voltage profile," in Universities Power Engineering Conference, 2007. UPEC 2007. 42nd International.
9. M. H. Sulaiman, O. Aliman, and S. R. Abdul Rahim "Contingency Analysis of Embedded Generation Deployment in Distribution Network" The 4th International Power Engineering and Optimization Conf. (PEOCO2010), Shah Alam, Selangor, MALAYSIA: 23-24 June 2010.
10. R. L. Haupt and S. E. Haupt, Practical genetic algorithms. NewYork: Wiley Pub, 1998.

AUTHORS DETAILS

Kota Shirisha Reddy was born in India in1991. She received the B. Tech. Degree in electrical engineering from the JNTU University, Hyderabad, A. P., India, in 2012 and M. Tech. From Osmania University in 2014. Currently, she is working as Assistant Professor in Electrical Engineering department of SNIST. Her current research interests include Renewable energy, Optimization techniques, stability.

L. Ramadevi was born in India in 1985. She received the B. Tech. Degree in electrical engineering from JNTU University, Hyderabad, A. P., India, in 2006 and M.Tech from Acharya Nagarjuna University, A.P in 2010.Presently she is Persuing Ph. D in Acharya Nagarjuna University, A.P. Currently, she is working as Assistant Professor in Electrical Engineering department of SNIST. Her current research interests include Renewable energy, Optimization techniques, Realiability, Distribution Generation, Smart Grid.

G. Sravanthi was born in India in 1987. She received the B. Tech. and M. Tech. Degrees in electrical engineering from the JNTU University, Hyderabad, A.P., India, in 2008 and 2010, respectively, currently, she is working as Assistant Professor in Electrical Engineering department of SNIST. Her current research interests include Renewable energy, power quality, FACTS, Power electronics, Smart Grid.

Koganti Sri Lakshmi was born in India in 1983. She received the B. Tech. and M. Tech. Degrees in electrical engineering from the JNTU University, Hyderabad, A.P., India, in 2006 and 2009, respectively, currently, she is working as Assistant Professor in Electrical Engineering department of SNIST. Her current research interests include Renewable energy, HVDC, Smart Grid, power quality, FACTS, and HVAC.